INDOOR AIR QUALITY ASSESSMENT

Hiram L. Dorman Elementary School
20 Lydia Street
Springfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Judy Dean, Western Massachusetts American Lung Association, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA), was asked to provide assistance and consultation regarding indoor air quality at the Hiram L. Dorman Elementary School (DES), 20 Lydia Street, Springfield, Massachusetts. On June 7, 2002, a visit was made to this school by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Ms. Dean during the assessment. Reports of inadequate ventilation, odors, lack of temperature control and other indoor air quality concerns prompted the assessment.

The school consists of two separate buildings. The original DES is a two-story red brick building with basement constructed in 1932. An annex, consisting of a two room, single story structure, was built in 1954. The DES annex is a freestanding structure and is the subject of a separate report. The DES contains general classrooms, main office, media center, kitchen and cafeteria/auditorium. The basement was originally constructed as an open area that was subdivided into offices, the former media center and teacher's lunchroom. Windows in both buildings are openable (see Picture 1).

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The school houses kindergarten through fifth grades with a student population of approximately 350 and a staff of approximately 30. Tests were taken under normal operating conditions and results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in nineteen of twenty-two areas surveyed, indicating inadequate air exchange in most areas of the school. It is important to note that the assessment occurred on a warm day (outside temp 84^{o} F) and a number of classrooms had carbon dioxide levels *above 800 ppm with windows open.* Increased carbon dioxide measurements indicates that open windows alone are not sufficient to provide adequate ventilation. At the time of this assessment, the ventilation system in a number of classrooms was deactivated, which would limit the introduction of fresh air into the building and contribute to increasing carbon dioxide levels.

Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. As mentioned, many univents were deactivated in classrooms throughout the school. Several univents also contained accumulated dirt/debris. These univents should be cleaned before operating to prevent aerosolization of these materials. In order for univents to provide fresh air as designed, intakes must remain free of obstructions but importantly, these units must remain “on” and be allowed to operate while these rooms are occupied.

The interior of a univent was opened and examined. Airflow into the univent is controlled by a pendulum louver (see Picture 2). The position of the pendulum louver determines the amount of fresh to return air from the classroom. The louver in Picture 2 is fixed in the closed position, preventing fresh air intake by the univent. It also appears that an insulating material is inserted between the bottom of the louver (see Picture 3) and the floor of the univent cabinet, effectively sealing the fresh air intake. Assuming that this univent is representative, the ventilation system is not able to draw fresh air from outdoors. The sole means for introducing fresh air into this building is through open windows.

An exhaust vent exists in each classroom, consisting of a hearth-like structure located on an interior wall at the floor (see Picture 4). Each exhaust vent is connected to an airshaft that runs from the roof to the basement. Classrooms were constructed around these shafts to provide exhaust ventilation. Pressurization created by the fresh air supply system also provides classroom exhaust ventilation. Airflow into each exhaust vent is controlled by a louver that is connected to a spring-loaded control mechanism (an Atlas Regulator) (see Picture 5). All exhaust vents appear to be set in the closed position, thereby preventing exhaust air from entering the airshafts. The moving of the handle of several Atlas Regulators released plaster, dirt and other debris onto the floor as louvers moved (see Picture 6). The means for draw of air (natural or mechanical) could not be determined since access to the roof could not be gained during this assessment. As with the univents, the position of exhaust vents would indicate that the exhaust vent system was similarly abandoned at some date prior to this assessment.

The basement is divided into rooms on the north and south sides of the central hallway. Rooms on the south side of the basement do not appear to have fresh air supplies. Openings were installed in adjoining walls that serve as passive air vents (see Figures 2 and 3). The exhaust vent (see Picture 7) in the Beebe office provides exhaust ventilation for room 1, the old media center and the storeroom. The passive vent connecting room 1 to the old media center was blocked with paper (see Picture 8). The motorized exhaust vent in the Beebe office was deactivated. Since these rooms do not have openable windows, they do not have any means of providing natural ventilation. The north side of the basement has a univent in the Ross office, with a passive vent serving as the supply for the LaPolice office. If the univent fresh air supply louver is disabled, no fresh air supply exists for these offices. No means for fresh air supply could be identified in the cafeteria nor the teacher's lounge.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. In its current condition, the DES ventilation system is incapable of being balanced. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix I.

Temperature readings ranged from 70° F to 76 ° F, which were within the BEHA recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. Temperature control is difficult in an old building with abandoned or nonfunctioning ventilation systems. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity ranged from 49 to 57 percent, which was within the BEHA recommended comfort range (see Tables). The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. It should be noted however, that relative humidity measurements were 3-11 percent higher than the relative humidity measured outdoors (46%) on the day of the assessment. This increase of relative humidity can be attributed to lack of airflow. Without airflow created by the ventilation system, water vapor from occupants can build up, as demonstrated by the relative humidity measurements.

Relative humidity in these buildings would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water-damaged ceiling plaster was observed in the second floor hallway and some classrooms (see Picture 9), which indicates a current or historic water penetration problem. Efflorescence (i.e., mineral deposits) was observed on second floor hallway ceilings. Efflorescence is a characteristic sign of water damage to building materials such as brick or plaster, but it is not mold growth. As moisture penetrates and works its way through porous building materials, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the material, water evaporates, leaving behind white, powdery mineral deposits. This condition indicates that water from the exterior has penetrated into the building. Water damaged building materials such as wall plaster and ceiling tiles can serve as a medium to support mold growth, especially if wetted repeatedly.

Water damage was also noted in the ceiling of the teacher's lounge (see Picture 10), which is attributed to leaks from plumbing/drains from the first floor boy's restroom. Leaks from urinal and toilet drains need to be repaired, cleaned and disinfected. In general, it is recommended that absorbent materials (e.g., gypsum wallboard, carpeting, fabrics, books, cardboard, etc.) be discarded once in contact with sewage (IICRC, 1999). Flooring (such as tile subflooring) should be evaluated, cleaned, disinfected, dried and sealed when appropriate (IICRC, 1999).

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Other Concerns

Several other conditions were noted during the assessment that can affect indoor air quality. Damaged fiberglass insulation was noted in the cafeteria (see Picture 11). Fiberglass insulation can be a source of skin, eye and respiratory irritation to sensitive individuals. A number of classrooms contained office supplies that contain irritants. Materials such as permanent markers may contain volatile organic compounds (VOCs), which can be irritating to the eyes, nose and throat of sensitive individuals.

Also of note was the amount of materials stored inside classrooms. In several areas, items were observed piled on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean in and around these areas. Dust can be irritating to the eyes, nose and respiratory tract. For this reason, items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

A number of univents had accumulated dirt, dust and debris within their air handling chambers, on coils, fans and other components (see Picture 12). These conditions can be attributed to the fact that no means for inserting filters exists in these univents. In order to avoid univents serving as a source of aerosolized particulates, the air handling sections of the univents should be regularly cleaned. However, without filters, dirt, dust and debris can easily collect within the units.

A fireplace exists in the media center (see Picture 13) which appeared to be no longer in use. The chimney for the fireplace likely exists on the roof. The top of the chimney may be open, which can allow rainwater to penetrate down the shaft. In addition, animals/pests may also enter the building through the chimney.

An abandoned water bubbler was noted in a hallway (see Picture 14). This bubbler is likely not to have recently drained water, which can lead to dry traps. A trap forms an airtight seal when water is poured down the drain. A dry trap can allow for sewer gas to back up into the building. Sewer gas can be irritating to the eyes, nose and throat.

Several complaints of vehicle exhaust and fuel oil odors during fuel delivery were reported. The pressure relief vent for the underground storage tank is near the back wall of the building (see Picture 15). Under certain wind conditions, fuel oil vapor may be directed toward the classrooms adjacent to the boiler room roof. Further, cars are parked at the base of the exterior wall near fresh air intakes for the basement classroom and open windows (see Picture 1). Idling vehicles can result in vehicle exhaust infiltration into the building. In turn, this can provide opportunities for exposure to products of combustion, including carbon monoxide. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1986).

Conclusions/Recommendations

The conditions noted at the Dorman Elementary School raise a number of issues. The combination of poor maintenance of the HVAC system, and the condition (or lack) of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the restoration of univent fresh air control dampers throughout the school.
2. Remove all blockages from univents to ensure adequate airflow. Clean out interiors of univents regularly. Have univents examined by an HVAC engineering firm to determine if univents can be fitted for filters.
3. Have an HVAC engineer examine exhaust vents for function and activate if operable.
4. Clean accumulated debris from exhaust vent louvers.
5. To maximize air exchange, the BEHA recommends that the ventilation system operate continuously during periods of school occupancy independent of classroom thermostat control.
6. If original mechanical ventilation systems are not fully restored in the original building, ensure abandoned exhaust and supply vents are properly sealed to eliminate pathways for movement of odors and particulates into occupied areas.

7. Regulate airflow in classrooms by using openable windows to control for comfort. Care should be taken to ensure windows are properly closed at night and on the weekends to avoid the freezing of pipes and potential flooding.

8. Remove blockages from passive vents in basement rooms and operate the exhaust fan in the Beebe office during school hours. Operate the univent in the LaPolice office during school hours.

9. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

10. Examine the exhaust vent system on roof. If openings exist, ensure exhaust ventilation shafts are properly secured with screens on the roof and inspect periodically to prevent occupation by birds and other pests.

11. Ensure plants have drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.

12. Consider relocating photocopiers and lamination machines to a well-ventilated area or examine the feasibility of installing local exhaust ventilation.

13. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
14. Encapsulate exposed pipe insulation to avoid the aerosolization of fiberglass fibers.
15. Store chemicals and cleaning products properly and out of the reach of students.
16. Consider sealing the abandoned chimney at roof level to prevent rainwater penetration and animal egress.
17. Schedule oil deliveries after school or when school is not occupied. If not feasible, notify school staff including classroom occupants in close proximity to the oil tank, in advance of scheduled delivery. This will avoid fuel odors/vehicle exhaust entrainment into classrooms.
18. Consider relocating parking spaces away from the building to prevent vehicle exhaust from being entrained by open windows.

The following **long-term measures** should be considered:

1. Based on the age, physical deterioration and availability of parts for ventilation components, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation system.
2. Examine the feasibility of repairing or replacing mechanical supply and exhaust ventilation systems in the building. Determine if existing airshafts, vents, ductwork, etc. can be retrofitted for (modern) mechanical ventilation.

3. Consideration should be given to providing a mechanical means to provide fresh air to all rooms in the basement.

4. Thermostat settings throughout the school should be evaluated. Thermostats should be set at temperatures to maintain comfort for building occupants.

References

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

IICRC. 1999. IICRC S500 Standard and Reference Guide for Professional Water Damage Restoration. 2nd ed. The Institute of Inspection, Cleaning and Restoration Certification, Vancouver, WA.

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OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Figure 2
Diagram of Airflow in South Half of DES Basement

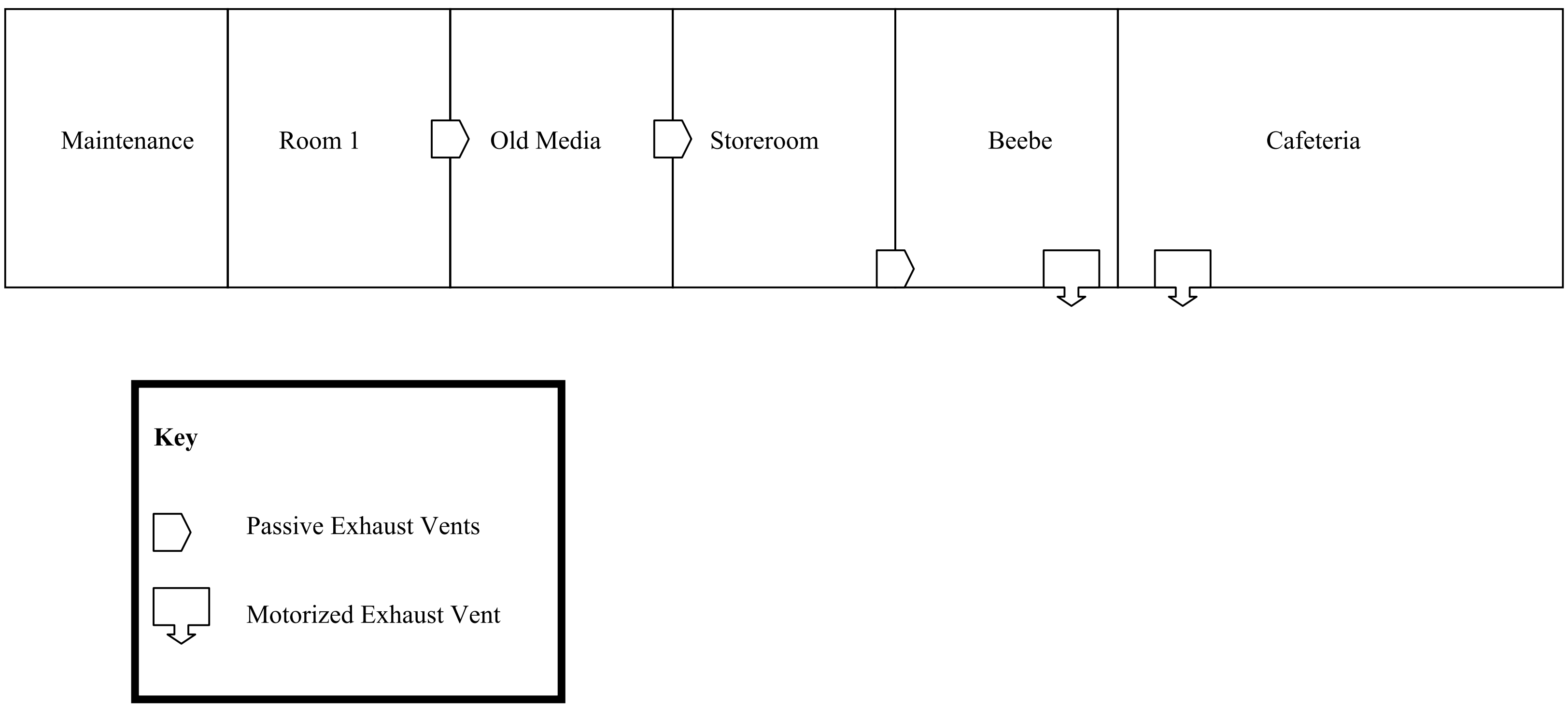
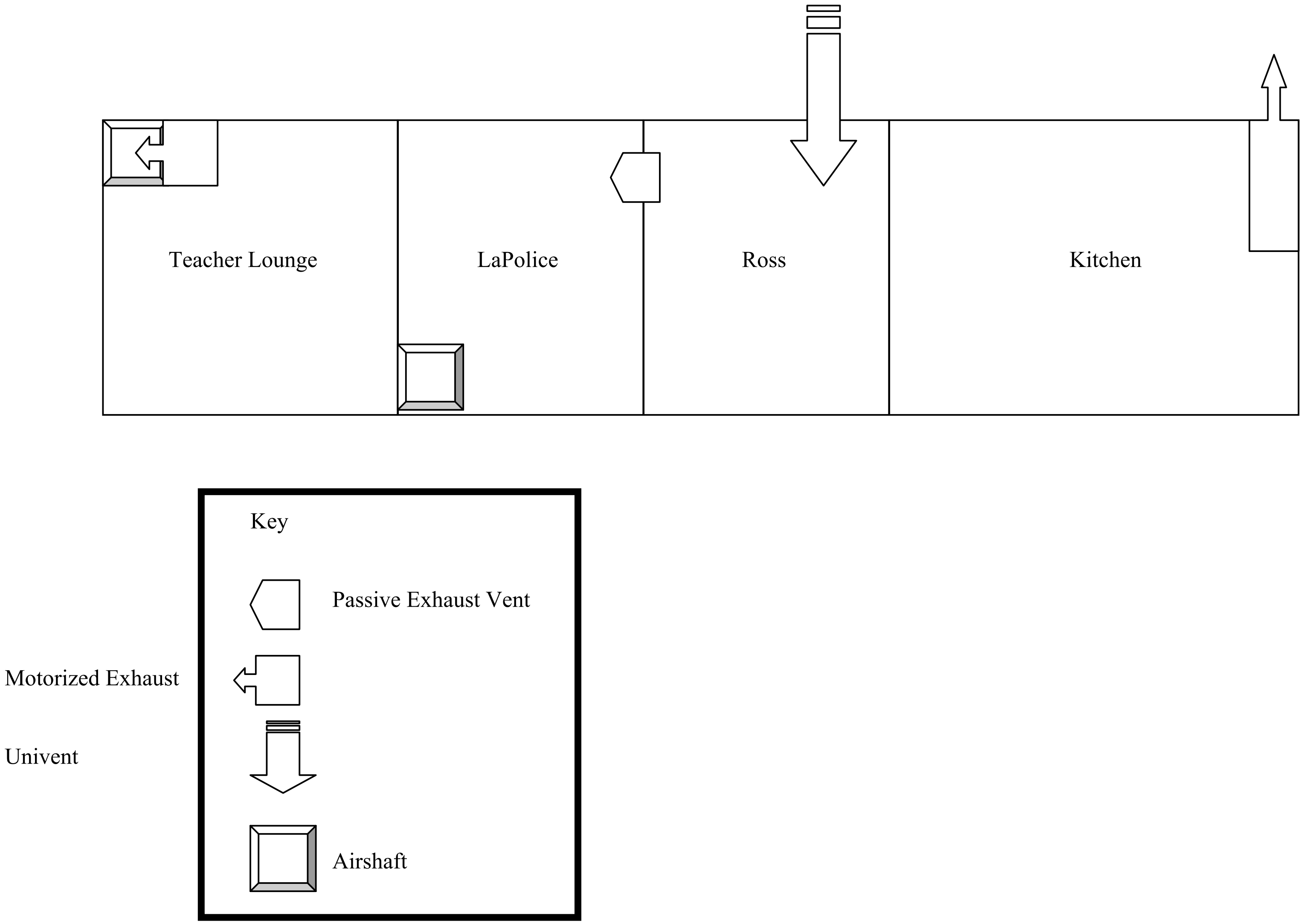


Figure 3
Diagram of Airflow in North Half of DES Basement



Picture 1

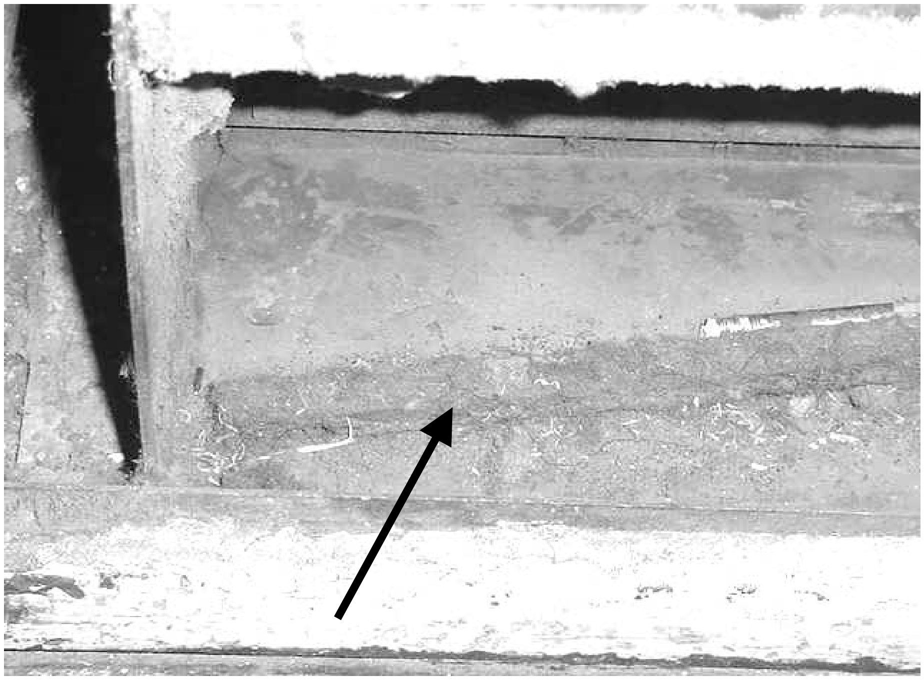
Openable Windows of DES on Basement Level

Picture 2

Louver Track

Pendulum Track For Louver

Picture 3



Insulating Material Inserted Between Louver and Cabinet Floor

Picture 4

Typical Exhaust Vent

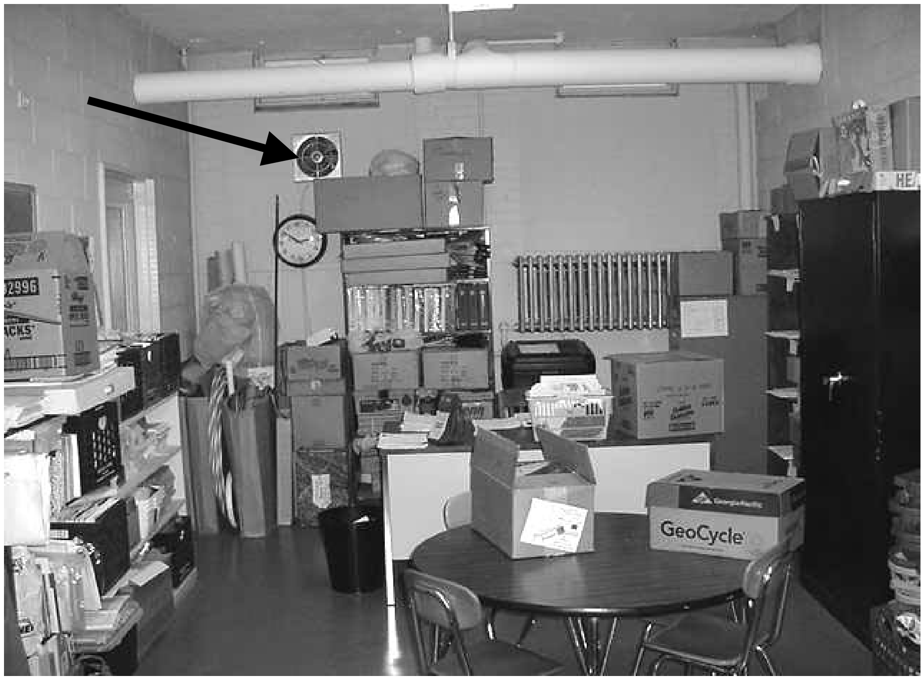
Picture 5

The Atlas Regulator (Exhaust Vent Louver Control)

Picture 6

Debris on Floor of Vent After Using the Atlas Regulator to Open the Vent Louvers

Picture 7



Exhaust Vent in Beebe Office

Picture 8

Passive Air Vent Blocked With Paper (Room 1)

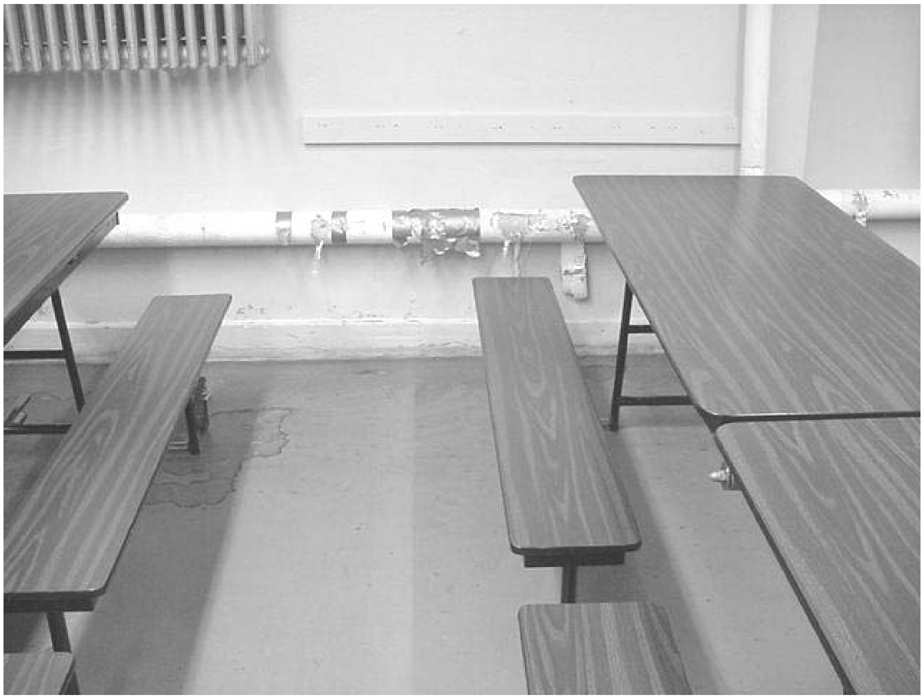
Picture 9

Water Damaged Plaster in 2nd Floor Hallway Ceiling

Picture 10

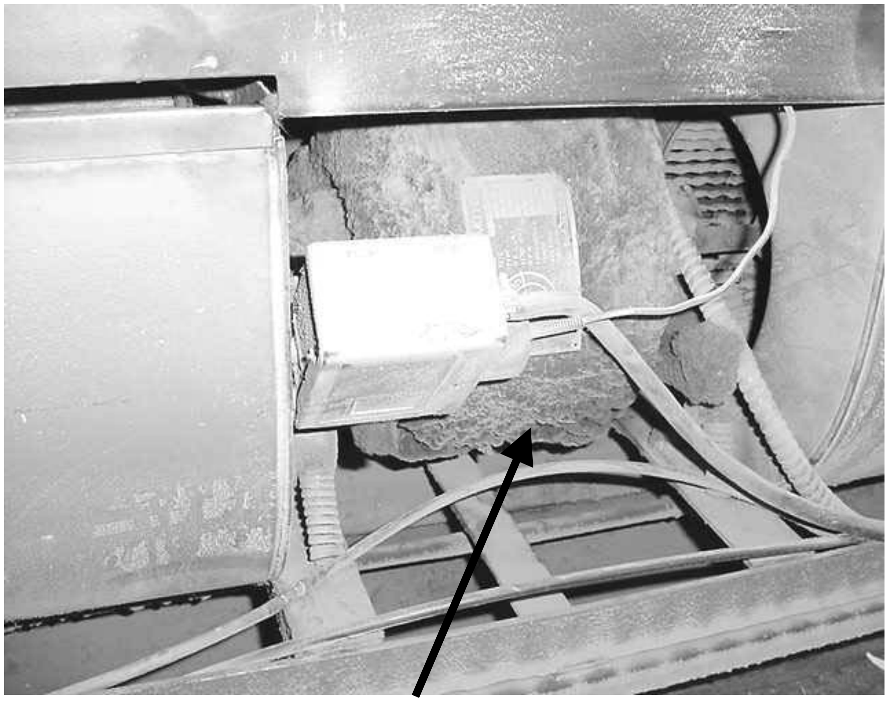
Water Damage Noted In the Ceiling of The Teacher's Lounge

Picture 11



Damaged Fiberglass Insulation In the Cafeteria

Picture 12



Accumulated Dust on Univent Motor

Picture 13

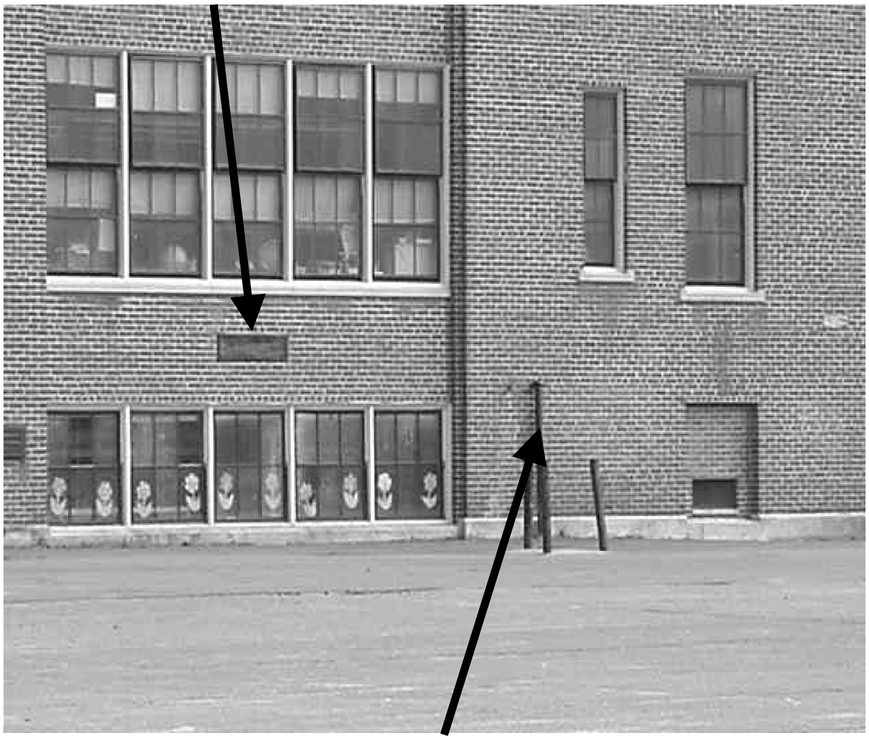
Fireplace

Picture 14

Abandoned Water Bubbler

Picture 15

Fresh Air Intake



Oil Vent Pipe

Oil Tank Relief Valve, Note Height In Relation To Window and Univent Fresh Air Intake

TABLE 1

Indoor Air Test Results –Dorman Elementary School, Springfield, MA – Springfield, MA = June 6, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	425	64	46					
Room 7	878	70	54	18	yes	yes	yes	univent off, exhaust closed
Room 9	1452	72	57	19	yes	yes	yes	univent obstructed by shelf, exhaust closed, accumulated items
Media Center (2:10)	859	74	54	8	yes	yes	yes	exhaust closed, chimney
Room 5	965	74	54	9	yes	yes	yes	univent off, plant
Room 4	707	73	49	1	yes	yes	yes	exhaust closed
Room 3	1090	73	50	38	yes	yes	yes	univent off, exhaust closed
Beebe Office	808	72	50	0	no	no	yes	exhaust off
Media Center (am)	707	73	52	1	yes	yes	yes	exhaust closed
DeCosmo	895	73	52	21	yes	no	no	accumulated itemsammonia containing cleaner

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Dorman Elementary School, Springfield, MA – Springfield, MA = June 6, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Com 10	845	73	51	15	yes	yes	yes	blackboard obstructing univent, exhaust closed, window open permanent markers
Com 14	1636	76	52	17	yes	yes	yes	exhaust closed, water-damaged ceiling, plants, door open
Room 11	1562	75	51	0	yes	yes	yes	table obstructing univent, box blocking exhaust
Room 15	1170	75	50	17	yes	yes	no	files obstructing univent, plant, water-damaged plaster
Room 12	922	75	49	0	yes	yes	yes	exhaust closed, window open
Room 16	1699	75	52	18	yes	yes	yes	exhaust closed, windows open
Room 13	687	74	50	0	yes	yes	yes	exhaust closed
Boy's Restroom						no	yes	exhaust off
Old Media Center	1370	72	54	8	no	yes	yes	water-damaged ceiling plaster
Ross	1133	74	53	7	yes	yes		passive vent in wall-covered with paper

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TABLE 3

Indoor Air Test Results –Dorman Elementary School, Springfield, MA – Springfield, MA = June 6, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 1	1607	73	51	0	no	no	yes	passive vent in wall-covered with paper
Cafeteria	1175	70	61	100+	yes	no	yes	window and door open
Teacher's Room	1033	72	58	7	yes	no	yes	exhaust off, water-damaged plaster, refrigerator, door open
LaPolice	978	73	51	0	yes	no	yes	

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